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(57) Abstract

Compositions and use of apodizing thin layer screens comprised of inert spreadable liquid polymer–dye combinations (quasi-liquid crystals) applied to and retained on the transparent surface of optical storage media capable of improving laser beam performance during writing and/or readout of encoded information in optical storage media such as compact discs, minidiscs, CD-ROMs/LDs/CD-Rs/CD-RWs/DVDs/DVD-Rs, etc.

INTERNATIONAL PATENT APPLICATION

USE AND MANUFACTURING APPLICATIONS OF POLYMER / DYE-BASED THIN LAYER COATINGS FOR ENHANCEMENT OF THE QUALITY OF RECORDING ON AND READOUT FROM THE OPTICAL STORAGE MEDIA

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SUMMARY OF INVENTION

Composition and use of polymers in appropriate solvent(s) with or without addition of selected dye combinations are proposed for developing a **thin-layer coating** on the transparent layer of optical storage media such as audio and video CDs. laser discs (LD) and DVDs **for improvement of the sound and/or video quality** during either recording and /or playback of the encoded digital information.

The invention can also be incorporated in manufacture of recordable (CD-R) and re-writeable CD (CD-RW) media. In that case, the proposed composition is applied on the polycarbonate transparent surface of optical storage media at the final stages of recordable media manufacturing.

DESCRIPTION OF INVENTION

The present invention submission relates to:

1) **use of polymer-dye compositions for thin film surface coating of optical storage media for improvement of laser beam characteristics** during writing and readout of the encoded information;
2) **selection of the type of natural or synthetic polymers and their derivatives**, possessing optical properties different and distinct from those composing optical storage media (eg, polycarbonate and acrylics) with the molecular structure, optical and surface retention properties such as to be capable of imparting to the finished optical storage media product noticeably improved accuracy of the information encoding (writing) and readout using laser beam technology as confirmed by analytical quality control evaluation systems.
3) **the selection of optimal concentrations of such polymers** including, but not limited to organo-silicone-derived polymeric compounds, in the complex multicomponent compositions;
4) **the selection and relative concentrations of specific additives** to the said composition including but not limited to natural and synthetic dyes and other organic and inorganic additives specifically selected to possess non-harmful properties with respect to the optical storage media substrate (eg., polycarbonate), and capable of enhancing the beneficial effects of selected natural or synthetic polymers and their derivatives upon the accuracy of the information encoding (writing) and readout using laser beam technology as confirmed by analytical quality control evaluation systems.
5) the method of application of the said polymer and/or polymer-dye compositions to optical storage media;
6) **use of said invention in the manufacture of optical storage media and in professional audio/video industry as well as in related consumer markets.**

STATEMENT OF THE INVENTION'S OBJECTIVE

Fundamentals of the compact disc optical storage technology – a brief summary

Optical information storage media such as CDs rely on high accuracy writing and readout of the encoded information by the optical devices (optical pick-ups) in dedicated apparatuses such as CD-ROM drives, CD and DVD recorders and players, etc. Information in such storage media can be encoded by a variety of physical and chemical means which **change the structure of the information layer**. The most widely used format of digital encoding is physical alteration of the data (information) layer expressed in the form of **precisely defined pits and lands**, waves, bubbles, etc. The accuracy of the writing and readout of the encoded information depends upon **fidelity of the laser optics device** for recording and playback as well as upon **optical characteristics of the transparent layer** of plastic (usually polycarbonate) of the CD / DVD.

While sophisticated **error correction algorithms**, e.g., Cross Interleave Reed Solomon code – CIRC, are used to compensate successfully for the inevitable random and spike errors during optical storage media readout, significant variables exist in the ability of CD players and CD-ROM drives to

accurately reproduce all of the encoded information. **Variations in the quality and light transmitting characteristic of the transparent polycarbonate layer** of the optical storage media also contribute to such inaccuracies.

The optical characteristics of the transparent polycarbonate layer are **critical also during the recording process** on recordable and re-writeable CD-R / CD-RW / DVD for the optimization of the geometry of the physical traces of the laser burning action on the recordable information layers in such recordable media.

In some cases, variations in the optical disc manufacturing process, the efficiency of error correction algorithms used as well as in optical and mechanical properties of the readout devices introduce noticeable errors in the readout. For reasons well understood by those versed in the art description of which is beyond the coverage of this submission, **low amplitude signals as well as those of high frequency and short duration are particularly prone to reproduction distortions** due to the less than optimal error correction of such encoded sounds during readout (J Halliday, 1996). Likewise, during recording on optical discs in appropriate recorders, **variation in or the presence of noise in the laser beam characteristics will result in distortion of timing and the pit geometry to a relatively greater extent affecting the smaller pits rather than longer pits** (J Halliday, 1996). Consequently, the information content carried in the smaller pits (more abundant in encoded **high frequency audio signals**) will be disproportionately affected during playback (J Halliday, 1996). On the other hand, **strong signals of high amplitude and relatively longer duration are less prone to be distorted** (see for example: Pohlmann, 1995).

In the case of audio optical storage media (eg CDs), **such deficiencies are perceived as frequency distortions, audible imperfections of sound** resulting in apparent loss of the encoded information. Various causes related to the laser light transmission process and reflection of the beams from the data layer of the optical storage media via the transparent (polycarbonate) layer of the optical storage media may account for this deficiency. Among such causes can be, but not limited to, the **unwanted light scattering, diffraction** and **reduced reflection** from the data layer, reflection from an interfering object, media and surfaces not intended to produce these optical aberrations.

The role of jitter in signal deterioration

The principle cause of audible imperfections is jitter. Essentially there are three main causes of jitter: **First**, imperfect geometry of the recorded pits themselves. "Anything which causes unwanted variations in the sizes of the pits will come out as jitter. One thing that can be significant is laser noise; that is, high-frequency variations in the power of the recording spot. Not surprisingly, if the power varies, the pits also vary in width and length, so when the CD is played the apparent pit lengths vary" (J Halliday, 1996). The **second "source of jitter** is the **influence of other pits nearby in the same track**. The **readout spot is broad enough that when the centre of the spot reaches the beginning of a short pit, the end of the pit lies within the fringes of the spot**. So the apparent position of the one pit end is slightly dependent on where the other end is. The same applies to short

lands. This is called **inter-symbol interference.** The jitter which arises from this is not truly random, but is associated with the pattern of recorded pit and land lengths" (J Halliday, 1996).

"Inter-symbol interference is worse at low recording velocities, because the pits are shorter and closer together. And **it is the cause of "deviation" of the pit lengths"**. ..... "If the shortest pits appear too short on playback, it is only because most of them are next to lands which are longer" (J Halliday, 1996). The "**third source of jitter is the crosstalk between pits in adjacent tracks, because the readout spot does not fall wholly on one track.** It is a largely random contribution. It is worse at lower recorded velocities, ***because the highest frequency components of the readout signal in the wanted track, with which the crosstalk is competing, are weaker"*** (italics and emphasis are ours) (J Halliday, 1996).

In order to reduce the undesirable effects of jitter one can give "***a gentle boost of the higher frequencies (so it relatively strengthens the signals from the shorter pits and lands)***, and to some extent it has the **effect of correcting for the effects of the optical resolution limitations which cause inter-symbol interference and crosstalk.** The deviation of the shorter pit lengths is likewise reduced" (italics and emphasis are ours) (J Halliday, 1996). These timing aberrations result in unwanted digital noise and deterioration of information retrieval from CDs/LDs/CD-Rs/CD-RWs/DVDs particularly demonstrable in transients. **The accuracy of readout depends among other things also upon on adequate reflection (and in part resulting cancellation) of the diode laser beam from the transition points of the pits and lands of submicron dimensions in the metallized data layer.** The minimum degree of expected reflectance beam is 70%. Reflectance of the recordable and re-writeable optic media (CD-Rs, CD-RW) is even lower. It is obvious, therefore, that improvement of the readout would occur if the data layer would have higher reflectance while the exterior polycarbonate surface of the optical storage media does not contribute to light scattering and reflectance.

NATURE OF THE INVENTION

The objective

The intention of this invention is to uniformly improve the accuracy of both the recording and readout of the encoded information through enhancement of the optical efficiency of transmission and reflection of the diode light beam. This can be achieved through the use of selected polymers and their combination with dyes in selected solvent systems compatible with the material of optical storage media (polycarbonates and acrylics, etc).

The primary objective of the invention was **to develop a simple and inexpensive approach to modify / improve the diode laser beam characteristics** in compact disc storage technology in order to achieve better resolution of the writing and readout of encoded information.

THE SCIENTIFIC BASIS FOR LASER BEAM REFINEMENT AND DEVELOPMENT OF APPROPRIATE COMPOSITIONS

Apodization

One of the primary objectives of laser beam improvement was to minimize the contribution of "noise" frequencies accompanying the laser beam at 780 nm. The presence of these "noise" frequencies may increase the probability of error in laser beam action both during writing and readout. Since cancellation of the laser beam or its complete reflection from the data layer is used to de-code the "0's" and "1's", **the presence of interfering light frequencies increases the probability of error as a result of incomplete cancellation or incomplete reflection.**

Imperfections of the pit and land geometry introduced during replication of the manufactured discs or in the process of encoding information in the data layer further increase the probability of readout errors.

While the **Reed-Solomon Cross-Interleave error correction system** efficiently eliminates all correctable errors without noticeable audible effect, it is possible that the very involvement of **the error correction systêm itself may help to "smooth out, average" some of the minor transient sonic details.** This may occur as a result of the relatively low presence of the encoding words for such transients compared to the overall contents of the sonic encoding.

To those versed in the art, one of the approaches to reduce the contribution of "sidelobe" frequencies in a light beam is to use **apodization screens.** This approach effectively "purifies" the main beam frequency of the accompanying "sidelobes, or noise". **As a result, the beam spot reaching the data layer becomes somewhat smaller.** This, however, **allows for a better resolution of the image of pits and lands of the data layer.**

I chose to use this apodization approach to attempt some "refinement" of the diode laser beam in CD players and CD writers.

In order to create such apodizing screens on optical storage compact discs, I selected to **use thin film coating with liquid compositions** that

- ♦ would **not require elevated temperature** curing,
- ♦ would not require **lengthy time exposures** and
- ♦ would **not introduce any structural chemical or physical alteration** of the manufactured product (CD, DVD, CD-R, etc):
- ♦ would be **able to produce noticeable improvement** in the quality of the encoded and reproduced information

Choice of coating substrates – NLO materials

The **field of nonlinear optical materials** has recently become an intensive area of basic scientific and applied technological research. Nonlinear optical (NLO) materials are active media allowing control of light wave propagation. In the development of optical storage media and

semiconductor technology, various NLO materials are constructed such that application of external stimuli such as electrical, optical, pressure and other influences **produces changes in the properties of NLO materials**. This can be used for either storage of information, detection of changes or other useful applications in technology (see for example: H Kuhn and J Robillard, eds. Nonlinear Optical Materials. CRC Press. 1992).

The objective of the present invention was to use certain properties of NLO compositions **only to improve laser beam characteristics** as described below. It relates only to optical properties of dye-polymer NLO materials which account for **generation of second order harmonic signals**. The extent to which second harmonic generation (SHG) of the NLO materials used in the present invention contributed to the observed improvement of laser beam performance (see Appendix section) has not been investigated. The present invention **does not** extend to NLO materials with specific optical and electromagnetic properties utilized in semiconductor industry such as generation of electric potential.

The selection of polymer/dye compositions was guided by the above considerations aimed at improving the properties of the laser beam entering the optically clear layer of the optical storage media to ensure improved writing and accurate readout of encoded information as reflected in the sonic and other performance characteristics (see Appendix section).

The polymers selected have an intrinsic molecular repetitive structure that imparts certain optically active characteristics to a thin layer formed by such polymers. **Among optical activity of polymer thin layers are refraction, linear and circular polarization, circular dichroism, reflectance, specific light wave absorption, diffraction**, etc.

The **physico-chemical basis for the formation of a thin layer coating** of the said polymer relates to the operation of physical forces at the air-plastic (polycarbonate) interface which result in **adsorptive spreading of the polymer-dye compositions in a thin layer upon evaporation of the organic solvent(s) carrier**. The repetitive molecular structure of the composing polymers is known to be retained upon adsorption onto a surface such as polycarbonate and to form a semi-permanent coating (see e.g., V Krongauz "Photochromic liquid crystal polymers" in Applied Photochromic Polymer Systems, pp 121-173, C B McArdle, ed., Chapman and Hall, NY, 1991)

Selection of the molecular characteristics of comprising polymers was **based upon the length of the monomer constituent units in the polymers** and of their derivatives as well as **upon their solubility properties in organic solvent(s)** and their appropriate concentrations in the said compositions.

While the detailed physico-chemical structure of the thin layers produced by such polymer-dye compositions is not available, **several plausible models may be visualized.**

Among these one can expect that

1) **the polymer–dye thin layer due to its optical characteristics (absorbance and refractive index) is capable of "filtering, screening out" light emissions of the laser diode** contaminating and interfering with the main monochromatic (780nm) beam of the diode. **This allows for a relatively "purified" beam to reach the information layer.**

Likewise, **the polymer–dye apodizing screen apparently prevents the attenuated "noise" light reflected from information layer to pass out of the polycarbonate layer and reach the photodiode.** This reduces interference with the reflected information-carrying main beam -- **consequently, a relatively "purified" reflected main beam can be registered by the photodiode of the optical pickup assembly;**

2) the polymer-dye thin film apodizing coating may **act as an optical refraction and/or diffraction lens contributing to the laser beam purity focused on the reflective data surface of the optical storage media;**

3) ordered molecular structure of polymers in the thin layer coating on the polycarbonate surface of the optical storage devices (CDs/LDs/CD-Rs/CD-RWs/DVDs) contributes to circular dichroism and **allows for the reduction of the reflectance of the incident beam** compared to that from untreated polycarbonate surface of the transparent layer of the CDs/LDs/CD-Rs/CD-RWs/DVDs. Undesirable reflectance of the untreated surface polycarbonate layer in effect reduces the amount of light intended to reach the information layer and subsequently to be reflected from it. Consequently, undesirable polycarbonate surface reflectance may result in less than optimal readout performance of the CD player;

4) SHG in the polymer-dye coating would produce **shorter light frequencies contributing to the more faithful formation of and/or readout of the pit-land geometry;**

5) due to the oriented nature of molecules retained in the polymer-dye coating, a **certain degree of circular dichroism can be expected to be associated with such thin film coating**. The circular dichroic nature of the coating contributes to the ellipticity of the passing light beam. Since the polymer-dye coating has a different refractive index than the underlying polycarbonate layer, **changes in ellipticity of the beam are likely to occur at the polymer-dye/polycarbonate interface** (see e.g., R Bruce and J Robillard, New Molecular Structures for Infrared Detection and Imaging, pp 89-113 in "Nonlinear Optical Materials", H Kuhn and J Robillard, eds, CRC Press, 1992). Improvement in the laser beam performance characteristics (increased reflectance, lower cross-talk – see Appendix section) indirectly **testifies to the reduction in the ellipticity of the laser beam by the polymer-dye coating;**

6) Finally, the **apodizing effect of the polymer-dye coating reduces the side-lobe frequencies and makes the beam spot somewhat smaller** also contributing to better formation of and/or readout of the pit-land geometry

All of these phenomena would result in more efficient performance of the optical pickup and more complete and accurate readout of the information encoded on optical storage media. It is widely recognized that the use of more sophisticated encoding (eg, 96 kHz/24 bit), sampling and readout systems is intended to reduce such distortions and imperfections resulting in a higher accuracy of audio

and/or video reproduction. Most of such digital technology improvement relying on optical readout would benefit from more accurate optical conditions at the disc–air interface.

PRIOR ART

Numerous reports and inventions are known related to coating processes in the optical storage media field. Our search of the patent literature as well as of published reports in scientific and technical fields related to optical storage media, laser beam treatment and/or coating processes **revealed no evidence of either existing or claimed surface coating technology, or compositions similar to or distinct from those described in the present invention that are specifically <u>intended to, designed for or claim to achieve enhancement of efficiency of recording on and readout of encoded information from optical storage media as a result of surface coating</u>** such as described in the present invention.

All of these describe technologies, uses and/or compositions either

a) relate to application of complex polymer-dye containing coating layers to serve as substrates for encoding digital information in these layers the latter being an integral part of the physical structure of the optical storage media in the process of its manufacture (eg., US Patent 5,609,990 Ha, et. al., 1997; US Patent 5,389,422 Okazaki, et. al., 1995; US Patent 5,470,626 Fleming, et. al., 1995), or

b) relate to surface coating processes intended to impart physical characteristics such non-glare, anti-reflection, anti-static, anti-scratch, etc. completely different in intent, composition, method of application and retention on surfaces from those of the present invention (eg., US Patent 4,578,266 Tietjen, et. al., 1986; US Patent 4,929,703 Narula, et. al., 1990; US Patent 4,942,065 Factor, et. al., 1990; US Patent 5,162,453 Hall, et. al., 1992; US Patent 5,486,578 Carpenter, II, et. al., 1996; US Patent 5,492,769 Pryor, et. al., 1996; US Patent 5,500,300 Eckberg, 1996; US Patent 5,518,788 Invie, 1996)

None of such improvements, inventions or technology either pre-date, compete with, contain claims identical or similar to those of the present invention, or constitute any part of or the entirety of the present invention.

To the best of our knowledge,

1) prior to the present invention there have been no technological developments similar to or specifically intended to **<u>effect surface treatment of optical storage media for the purpose of modification and improvement of the laser beam characteristics during recording or readout of the encoded information</u>**;

2) furthermore, to the best of our knowledge, prior to the present invention **<u>there have been no technological developments specifically intended to use apodization screens to effect modification and improvement of the laser beam characteristics in relation to the optical storage media</u>;**

3) additionally, to the best of our knowledge, prior to the present invention there have been no technological developments **<u>specifically intended to use apodization screens to impart enhanced sonic characteristics of the audio compact disc technology;</u>**

4) likewise, to the best of our knowledge, prior to the present invention there have been no technological developments <u>**potentially capable of or specifically intended to use apodization screens to impart enhanced video characteristics of the compact disc technology**</u>.

THE APPLIED CONSEQUENCES OF THE INVENTION

Polymer compositions were selected such that their absorption characteristics would be compatible with the bandwidth of the coherent laser diode emitted light generated by the optical pickup of the CD players, CD ROM drives (commonly 780-810 nm), and DVD players (shorter wavelengths).

Selection of the polymers was aimed **among other objectives to produce a degree of screening of the diode light beam at the wavelengths outside the intended coherent bandwidth of 780 to 810 nm.** It is known that light at lower and higher wavelengths than 780-810 nm is frequently generated by such diodes constituting the noise component of the beam.

It is believed that this "undesirable" light noise may interfere with accurate performance of the data writing and reading primary beam as well as with tracking and focusing correction signals by the secondary beams (eg, I3/ITOP, I11/ITOP, I3/ITOP range).

Of particular significance is the fact that **recordable optical disc media such as CD-R and CD-RW feature lower reflectivity than manufactured CD and CD-ROMs.**

Reduced reflectivity imposes additional requirements on the recording and/or reading laser beam expected to accurately perform either burning of pits or reading of the encoded pits in a reduced reflectivity environment.

Since optical pickup action fundamentally depends on accurate cancellation of the incident and reflected beams, **the reduced reflectivity requires changes in the beam characteristic such as intensity**. A number of additional conflicting demands on the optical pickup assembly and the servo systems associated with it are thereby imposed by the reduced reflectivity of recordable and re-writeable optical storage media. In this context, **any enhancement in beam reflectivity from recordable optical storage media not requiring an increase in the laser beam power is desirable.**

The present invention effectively achieves enhancement of the reflectivity of the laser beam from the information layer as demonstrated by the analytical measurements (eg, I3/ITOP, I11/ITOP, I3/ITOP range) of the coated and uncoated identical manufactured (CDs) and recorded (CD-Rs) optical storage discs.

Furthermore, given the apodizing effect of the present invention upon the laser beam, **the reduced half-intensity beam spot that is used during the recording and playback from optical storage media, will reduce the effect of fluctuation in the laser beam characteristics that otherwise result in imperfect pit geometry.**

Consequently, the optical storage media **pre-coated with the present invention** either at the manufacturing stage or by the end-user **will result in more accurate encoding and subsequently reproduction** of the digital data.

Furthermore. **the proposed composition has characteristics consistent with apodizing properties of a thin film created with the said composition.** In its apodizing capacity the said composition coating will produce the desired refinement action of the laser beam characteristics.

Namely, **the Airy pattern maximum will be slightly reduced and the accompanying minor light frequency components will be drastically reduced.**

As a result, since the optical storage media utilize optical reflectance as its fundamental operating principle of encoding and readout of information, **the "refinement" of the laser beam as produced by said invention will result in a more faithful production of or readout of geometrical alterations in the information layer (pit and lands) of the optical media produced or read by the laser beam.**

TECHNICAL CHARACTERISTICS, PERFORMANCE AND ANALYTICAL DATA

Support of the proposed mechanism of action of the invention is found in the analytical data measuring the accuracy of digital and analog signals from pre-coated and recorded or coated following production for purposes of playback. The analysis has been conducted on CD Associates CD evaluation system. Comparison has been made between identical CDs -- an uncoated one and that coated with the product of invention. The most significant **consistent results of the present invention** proved to be (see Appendix section):

1) **enhancement in effective reflectivity** of the beam from the invention coated CDs manifested in **increased I3/ITOP, I11/ITOP ratios,**
2) **up to four-fold enhancement in the I3/ITOP range** in the coated CDs,
3) **reduction in the push-pull values** (testifying to the reduction in the strain of the servo system of the optical pickup),
4) **reduction in the crosstalk** and **jitter**,
5) **increase in the scanning velocity,**
6) **elimination of de-tracking,**
7) **elimination of uncorrectable errors (E32 errors)**

Crosstalk represents interference of the reflected beam from neighboring pits and lands as well as from neighboring tracks. This interference significantly reduces the reliability of the accurate digital recording/encoding and readout. The effect of crosstalk increases with the increase in the density of information recording as in DVDs (in comparison with CDs).

The dramatic benefit of the coating was also represented by **reduction in the time deviation** parameters of the coated CDs – **reduction by two orders of magnitude**. bringing the time deviation from eg.. 17.2 ns to 0.1 ns. The latter result testifies to the desirable elimination or reduction of the data-to-data jitter component most noticeable in the quality, accuracy of the recorded/reproduced audio/visual signal. Coincident with that the **scanning velocity** of all coated discs **was increased** by some 5%. Furthermore, the enhancement of the performance characteristics of the coated discs was noted in complete **elimination of the uncorrectable E32 errors** and **de-tracking.**

As a result on the present invention, one perceives, for example, in **audio CD playback**, a **substantially enhanced presence of audio detail.** Similar enhancement is noted **also in CD-R recorded on CD-R and CD-RW recorders** at 1x, 2x and 4x speeds (eg., Yamaha brand) and played back on conventional CD players (eg., Denon, Sony).

The audible detail enrichment effect is retained in pre-coated CD-Rs from which the present invention coating is removed after recording and prior to playback. This indicates that the present invention **affords its improvement during the process of writing/encoding** information onto the CD-R by conventional means.

Again the improvement during writing on CD-Rs is primarily accounted for by the **notably pronounced and highly reproducible presence of the high frequency, usually low level and short duration audio signals.** When consistently added to the playback signal, the **subjective perception of the improved signal is that of a "virtual presence" phenomenon, realistic space visualization, true-to-life sound coloration**, the appearance of micro echoes normally heard in live performances or in nature.

ADVANTAGES OF THE PRESENT INVENTION

Advantages of the present invention over other similar products claiming sound enhancement are:

1) distinct **quantitative, measurable and documented consistent** and **reproducible enhancing effects** on the **technical characteristics** and **performance** of the optical storage media in recording and playback;
2) **longevity of the thin layer** produced by application of the said polymer–dye mixture on the surface of the transparent layer of polycarbonate of the optical storage media;
3) **ease and fastness** of application of the product;
4) **non-damaging nature** of the product to the plastic material(s) of the optical storage media;
5) **low cost** of the product per application;

Additional benefits include:

a) the resulting **anti-static properties** of the treated optical storage media,
b) an enhanced degree of **mechanical protection** of the transparent optical storage media layer of the polycarbonate following the present invention polymer-dye application;
c) an enhanced **resistance to contamination** of the optical storage media transparent surface by spillage;
d) **ease of removal** of the thin layer or its modification / improvement by subsequent application of the said composition; compatibility with conventional optical storage media cleaning methods, reagent and techniques;
e) ability to restore the enhanced property **by re-application** of the said coating by the user and.

f) **suitability to modification by alternative formulations** of similar of different polymer compositions without any degree of deterioration of the original optical storage media polycarbonate transparent layer.

METHOD OF APPLICATION

The product is composed in **volatile organic solvents** such as short chain aliphatic hydrocarbons, including but not limited to hexane and heptane, allowing for rapid evaporation of the carrier solvent. As a result, the polymer-dye thin film is deposited and adheres to the polycarbonate substrate of the CD. An amount equal to 0.1-0.2 mL per 12 cm in diameter CD surface is evenly distributed and proves to be sufficient to produce the said sound improvement effect.

The product **can be applied either manually** (eg., by a spray) or mechanically followed by an even distribution of the mixture over the entire surface of the optical storage media. Pooling, unevenness of distribution, excessive concentration and smearing of the product on the transparent polycarbonate optical storage media surface should be avoided.

Alternatively, **the product can be applied automatically** in a specially designed apparatus (Patent Application in preparation) that combines application and controlled, reproducible uniform distribution of the mixture over the optical storage medium surface.

The entire manual **procedure requires 10-15 seconds** to complete. Shorter times can be easily achieved with mechanical devices without any deterioration in the degree of sound improvement achieved by the polymer-dye mixture application.

CLAIMS

1) **Use of apodizing screens on the transparent surface of optical storage media composed of spreadable liquid polymer-dye films (quasi-liquid crystals) for the improvement of laser beam characteristics** during writing or readout of encoded information in optical storage media such as compact discs (CDs/LDs/CD-Rs/CD-RWs/DVDs, etc);
2) The rationale for the selection of the type of natural or synthetic polymers and their derivatives, possessing **optical properties different and distinct from those composing optical storage media** (eg, polycarbonate and acrylics) and with appropriate molecular structure and with such optical and surface retention properties as to be capable upon thin layer coating of such media with the selected compositions of imparting to the finished optical storage media noticeably improved accuracy of the information encoding (writing) by a laser beam technology and readout by a laser beam technology from optical storage media as confirmed by analytical quality control evaluation systems;
3) **Use of thin layer coating applied on the transparent layers of optical storage media** products of natural or synthetic polymers and their derivatives, **possessing optical properties different and distinct from those composing optical storage media** (eg, polycarbonate and acrylics) and with appropriate molecular structure and with such optical and surface retention properties as to be capable of forming such a retentive thin layer coating on optical storage media and imparting to the finished optical storage media noticeably improved accuracy of the information encoding (writing) by a laser beam technology and readout by a laser beam technology from optical storage media as confirmed by analytical quality control evaluation systems;
4) Use and composition of thin layer coating mixtures consisting of natural or synthetic polymers and their derivatives, **possessing apodizing optical properties** and **with appropriate molecular structure and surface retention properties** as to be capable upon thin layer application upon transparent surface of such media of imparting to the finished optical storage media noticeably improved accuracy of the information encoding (writing) by a laser beam technology and readout by a laser beam technology from optical storage media as confirmed by analytical quality control evaluation systems;
5) Use and composition of mixtures of natural or synthetic polymer(s) and dye(s) and an additive(s) for the treatment of transparent surfaces of optical storage media (CDs/LDs/CD-Rs/CD-RWs/DVDs) comprising but not limited to mixtures of **linear and/or branched derivatives of organo-silicones and dyes** such as, but not limited to, rhodamines, fluorescein derivatives, proprietary fluorescent compounds, methylene blue, optical brightners soluble in solvents, including but not limited to nonpolar solvents, compatible with polycarbonate and other plastics used in manufacture of optical storage media;
6) **Use of said polymer-dye compositions for coating** optical information storage media such as CDs/LDs/CD-Rs/CD-RWs/DVDs etc. **during pre-recording of recordable optical storage media such as CD-R or CD-RW** with the purpose of enhancing the correctness and degree of details of the

information recording onto such devices by appropriate apparatuses in professional and consumer utilization:

7) **Use of said polymer-dye compositions for coating** optical information storage media such as CDs/LDs/CD-Rs/CD-RWs/DVDs etc. **during playback** with the purpose of enhancing the correctness of information readout from such devices by appropriate apparatuses of professional and consumer utilization;
8) Use of apodizing screens as described in the present invention **achieving the improvement of recording and reading laser beam characteristics** **without modification of the optics, physical structures, and their optimized parameters** developed and maintained by the international technology consensus for compact disc technology applications;
9) Use of said compositions **as the foundation for further enhancement of the mixtures by addition of components known to further affect optical properties of thin layers** produced by applying such compositions onto the surface of optical storage media including but not limited to organic and synthetic dyes, fluorescent dyes, optically active compounds including polymers, metals, dyes and other organic and inorganic molecules known to have optical activity enhancing that of the foundation mixture.

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United States Patent 4,929,703 Narula, et. al., 1990 Solventless silicone coating composition

United States Patent 4,942,065 Factor, et. al., 1990 Method for curing silicone coatings on plastic substrates, and curable compositions related thereto

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United States Patent 5,470,626 Fleming, et. al., 1995 Optical recording layers containing sulfur

United States Patent 5,486,578 Carpenter, II, et. al., 1996 Curable silicone coatings containing silicone resins

United States Patent 5,492,769 Pryor, et. al., 1996 Method for the production of scratch resistance articles and the scratch resistance articles so produced

United States Patent 5,500,300 Eckberg, 1996 Silicone fluids having chloroalkyl and epoxy groups and photocurable silicone coating compositions

United States Patent 5,518,788 Invie, 1996 Antistatic hard coat incorporating a polymer comprising pendant fluorinated groups

United States Patent 5,609,990 Ha, et. al., 1997 Optical recording disk having a sealcoat layer

Victor A. Bernstam

Victor A Bernstam, MD, PhD

APPENDIX: ANALYTICAL MEASUREMENTS OF THE EFFECTS OF THE PRESENT INVENTION ON THE PERFORMANCE OF CDs

Definitions

Definitions of Analytical Measurements of CD as defined by Optical Storage Technology Association (OSTA). These measurements were used in and are referred to in the analytical evaluation (See attached) of the effects of the present invention on performance of CDs.
OSTA CD-R Compatibility Study
(OSTA-6. Revision 1.00, 15 August 1997) 4.2.1 - Description of the Performance Parameters Utilized in the OSTA Study as presented at http://www2.osta.org/osta/html/cdrcomp/perf.html

Compact disc analysis involves a wide range of electrical and physical measurements under the Sony/Philips Red Book specification. The CD Associates Quick Test rack system organizes these measurements into 5 categories: digital error, analog signal measurement, physical measurements, optical measurements and format verification. The following parameters were included in the first round of the OSTA testing:

Digital Error

BLER - Block Error Rate. This count represents the total number of symbol corrections made by the C1 decoder in any one-second. It is the combination (E11+E21+E31) of C1 activity for any given second. BLER is presented in the data as a value averaged across the disc.

BLER 10 Second Max - A one-second maximum value averaged across a running 10 second reading. The Red Book specification allows for a maximum reading of 220 cps. This parameter is a very popular measurement in optical disc manufacturing.

BURST - This count represents the number of two symbol error corrections per second that are greater than 7. Burst is an indicator of non-random error and usually is used to identify the presence of physical errors such, as scratches or macroscopic marks.

BURST MAX - This count represents the maximum one-second burst error count across a testing period.

UNCR MAX - This count represents the maximum one-second unrecoverable error count across the testing period. Any count here represents an error that was unrecoverable in the C2 decoder. Any value here is out of specification. All discs should be free of Uncorrectable errors.

Analog Measurements

I11/ITOP - represents the peak-to-peak value of the HF signal component generated by the longest pit structure. The value is normalized by the peak value of the HF signal (Itop).

I11/ITOP MIN - represents the one-second minimum value of I11/Itop across a testing period. The minimum allowable I11/Itop value the Red Book is 0.600.

I3/ITOP - represents the peak to peak value of the HF signal generated by the shortest pit structure. The value is normalized by the peak value of the HF (Itop).

I3/ITOP MIN, MAX - represents the one-second maximum and minimum values of I3/Itop across a testing period. The Red Book specification allows for a minimum value of 0.30 and a maximum value of 0.70.

ASYMMETRY - represents the relationship of the land/pit area. A positive asymmetry value represents a pit area that is larger than its associated land area. The Red Book specification allows for Asymmetry values as high as +20%. However, it is noted that many players have trouble reading values that are lower than -15%. SYMMETRY, the inverse of ASYMMETRY, is often used in its place. In contrast, the Orange Book utilizes a parameter beta (b) which is very nearly equal to Asymmetry. The Orange Book requires that a CD-R disc be written (at 1X or 2X speed) such that $0 < b < 8\%$ which is a much more restrictive condition that the Red Book requirement. The Orange Book further requires that b vary by no more than ±2% over the whole recorded disc.

ASYM MIN, MAX - represents the one-second minimum and maximum Asymmetry reading across the testing period.

PUSH-PULL, MIN, MAX - represents tracking signal magnitude. This value of this parameter is normally out of the Red Book range for CD-R media. The Red Book allows for a push pull range of 0.04 to 0.07. The Orange Book specification extended the upper end of the specification to 0.09. Much of the data collected represents push-pull values higher than that designated Orange book specification. Too much tracking signal can be a problem for one-beam players that depend on a the push-pull signal to support the tracking system. It is rarely a problem for CD-ROM drives. The vast majority of media in this test was out of specification for push-pull.

RADIAL NOISE, MAX - represents a signal noise measurement in the tracking signal. The noise component in the tracking signal is measured between 500 Hz and 2500 Hz, and the resulting value is normalized by the push-pull signal. The specification allows for radial noise measurements up to 30 nm. Radial noise is usually generated by physical flaws in the disc.

CROSS TALK, MAX - is a measurement of the relationship of the signal strength on the track to the signal strength between the tracks. According to specification the off-track values must be less than 50% of the on-track value.

AMENDED CLAIMS

[received by the International Bureau on 14 October 1998 (14.10.98); original claims 1-8 amended ; remaining claim unchanged (2 pages)]

Amended CLAIMS

1) **Use of apodizing screens composed of spreadable liquid polymer-dye films (quasi-liquid crystals) applied directly to and retained on the transparent surface of optical storage media for the improvement of laser beam characteristics** during writing or readout of encoded information in optical storage media such as compact discs (CDs/CD-ROMs/LDs/CD-Rs/CD-RWs/ DVDs/DVD-Rs, etc);

2) The **method for selecting chemical compositions** either from existing chemicals or newly developed which do not enter into chemical bonding, reversible or irreversible chemical interaction(s) with the material(s) composing optical storage media and which are comprised of natural or synthetic polymers and/or their derivatives and/or dyes such that said compositions possess **optical properties different and distinct from those of materials composing optical storage media** (eg, polycarbonate and acrylics) and have **the molecular structure, optical and surface retention properties such** that upon thin layer coating of optical storage media with the said compositions they improve accuracy of the information encoding in (writing) and readout from optical storage media such as compact or mini-discs (eg., CDs/CD-ROMs/LDs/CD-Rs/CD-RWs/ DVDs/DVD-Rs. etc) using laser beam technology as confirmed by specialized analytical instruments evaluation;

3) **Use of thin layer coating applied on the transparent layers of optical storage media** products of natural or synthetic polymers and their derivatives, **possessing optical properties different and distinct from those composing optical storage media** (eg. polycarbonate and acrylics) and with appropriate molecular structure and with such optical and surface retention properties as to be capable of forming such a retentive thin layer coating on optical storage media and imparting to the finished optical storage media noticeably improved accuracy of the information encoding (writing) and readout by a laser beam technology from optical storage media as confirmed by analytical quality control evaluation systems;

4) Composition of thin layer coating mixtures consisting of **natural or synthetic polymers and/or their derivatives, possessing apodizing optical properties** and **with appropriate molecular structure and surface retention properties** as to be capable when applied as a thin layer upon transparent surface of such media of imparting to the optical storage media noticeably improved accuracy of the digital information encoding (writing) and readout by a laser beam technology from optical storage media as confirmed by analytical quality control evaluation systems;

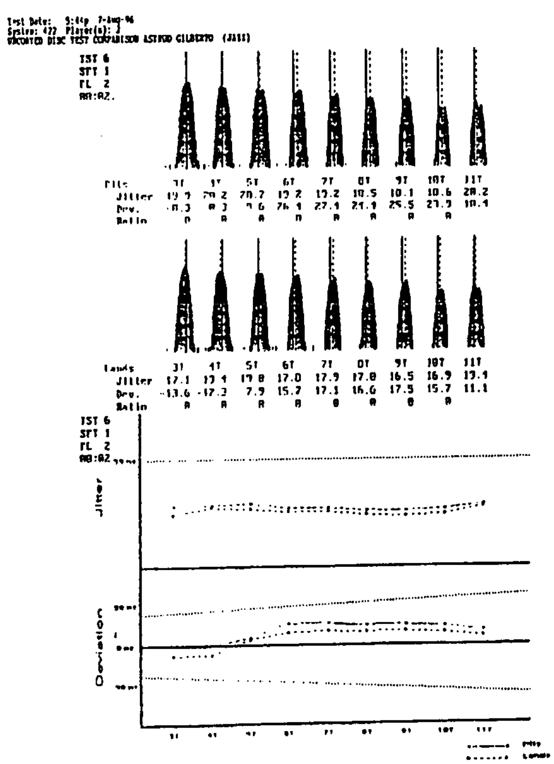
5) Composition of thin layer coating mixtures of natural or synthetic polymer(s) and/or their derivatives **also comprising dye(s) and an additive(s)** for the treatment of transparent surfaces of optical storage media (eg., CDs/CD-ROMs/LDs/CD-Rs/CD-RWs/DVDs/DVD-Rs, etc) comprising but not limited to mixtures of **linear and/or branched derivatives of organo-silicones and dyes** such as, but not limited to, rhodamines, fluorescein derivatives, proprietary fluorescent compounds, methylene blue, optical brightners soluble in solvents, including but not limited to nonpolar solvents, compatible with and not chemically interacting with polycarbonate and other plastics used in manufacture of optical storage media;
6) **Use of said polymer-dye compositions for coating** optical information storage media such as CDs/CD-ROMs/LDs/CD-Rs/CD-RWs/DVDs/DVD-Rs, etc. **either during manufacture of or after manufacture prior to recording on recordable optical storage media such as CD-R, CD-RW, DVD-R, DVD-RW** with the purpose of enhancing the performance characteristics of the media such as correctness and degree of details of the information recording onto such devices by appropriate apparatuses in professional and consumer utilization;
7) **Use of said polymer-dye compositions for coating** optical information storage media such as CDs/CD-ROMs/LDs/CD-Rs/CD-RWs/DVDs/DVD-Rs/DVD-RWs, etc. **either during manufacture of or prior to playback** with the purpose of enhancing the correctness of information readout from such devices by appropriate apparatuses for professional and consumer utilization;
8) Use of apodizing screens as described in the present invention capable of **improving laser beam characteristics during recording and reading digital information <u>not requiring modification of the optics, physical structures, and their optimized parameters</u>** already in existence or to be developed and maintained by the international consensus for optical storage media technology applications otherwise functional in the absence of utilization of the present invention;
9) Use of said compositions **as the foundation for further enhancement of the mixtures by addition of components known to further affect optical properties of thin layers** produced by applying such compositions onto the surface of optical storage media including but not limited to organic and synthetic dyes, fluorescent dyes, optically active compounds including polymers, metals, dyes and other organic and inorganic molecules known to have optical activity enhancing that of the foundation mixture.

Table 1

NOTE: In this and other tables LUSON is a Trademark registration pending name for the intended commercial version of the present invention

Sample Comparison of Test Results of Untreated and LUSON® -treated CD (Astrud Gilberto)

	UNTREATED	LUSON®	CHANGE DUE TO LUSON®
DIGITAL			
BLER (220)	0	0	
E11 (220)	0	0	
E21 (200)	0	0	
E31 (200)	0	0	
BRST (7)	0	0	
E12 (300)	0	0	
E22 (2)	0	0	
E32 (1)	0	0	
De-track (track jumping)	**2**	**0**	**Defect Elimination**
ANALOG			
I11 / ITOP	0.717 (0.600)	0.745 (0.600)	▲4%
I3 / ITOP	0.528 (0.300)	0.538 (0.300)	▲2%
I3 / ITOP Range	0.02	0.08	▲400%
SYM	-4.1 (-20.0—20.0)	-5.0 (-20.0—20.0)	▲10%
Rad Noise	10.2 (30.0)	10.1 (30.0)	▼0.1%
PP Mag	0.062 (0.040)	0.054 (0.040)	▼15%
Jitter / Pits	19.4 (35.0)	19.0 (35.0)	▼2%
Jitter / Lands	17.9 (35.0)	20.9 (35.0)	▲16%
Cross Talk	32.7 (50.0%)	30.3 (50.0%)	▼10%
Deviation / Pits	17.2 (50.0 ns)	0.1 (50.0 ns)	▼99%
Deviation / Lands	8.4 (50.0 ns)	0.1 (50.0 ns)	▼99%
Scan Velocity	1.33	1.39	▲5%



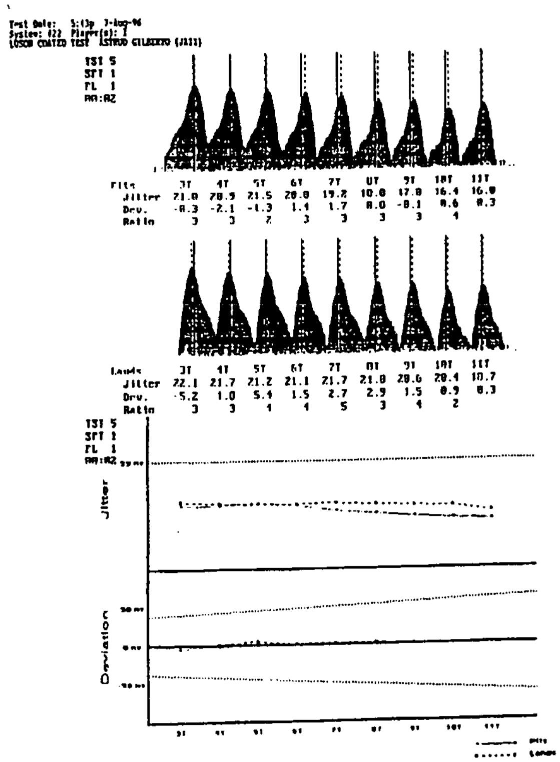
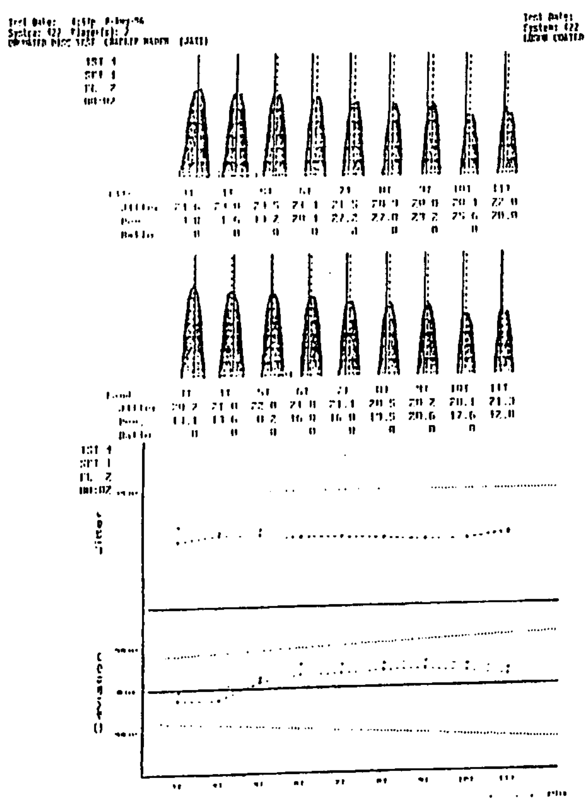


Table 2

Sample Comparison of Test Results of Untreated and LUSON® -treated CD (Charlie Haden)

	UNTREATED	LUSON®	CHANGE DUE TO LUSON®
DIGITAL			
BLER (220)	0	0	
E11 (220)	0	0	
E21 (200)	0	0	
E31 (200)	0	0	
BRST (7)	0	0	
E12 (300)	0	15	
E22 (2)	0	18	
E32 (1)	0	0	
De-track (track jumping)	1	0	Defect Elimination
ANALOG			
I11 / ITOP	0.648 (0.600)	0.688 (0.600)	▲6%
I3 / ITOP	0.462 (0.300)	0.494 (0.300)	▲7%
I3 / ITOP Range	0.02	0.08	▲400%
SYM	-2.2 (-20.0—20.0)	-3.0 (-20.0—20.0)	▲36%
Rad Noise	9.7 (30.0)	7.3 (30.0)	▼25%
PP Mag	0.080 (0.040)	0.075 (0.040)	▼9%
Jitter / Pits	19.7 (35.0)	18.1 (35.0)	▼8%
Jitter / Lands	18.8 (35.0)	20.0 (35.0)	▲6%
Cross Talk	39.6 (50.0%)	34.9 (50.0%)	▼12%
Deviation / Pits	16.9 (50.0 ns)	1.8 (50.0 ns)	▼90%
Deviation / Lands	8.4 (50.0 ns)	2.9 (50.0 ns)	▼65%
Scan Velocity	1.33	1.39	▲5%



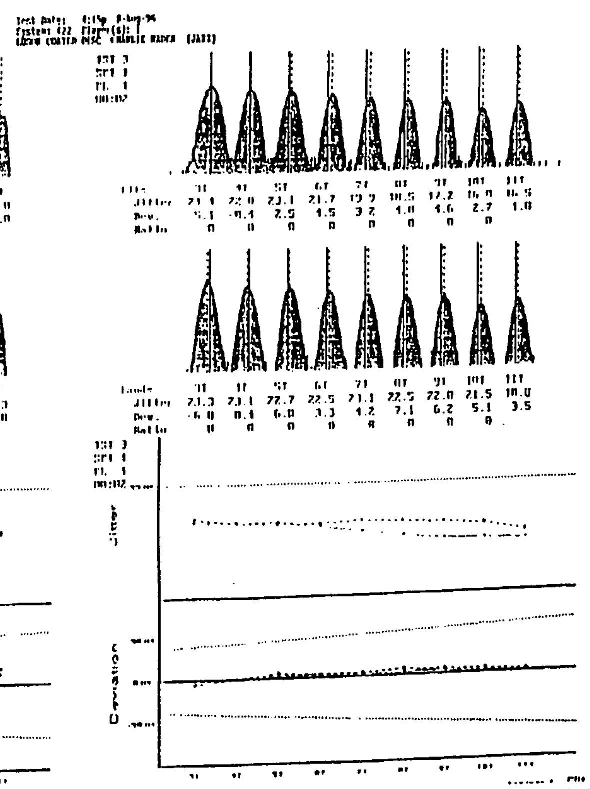
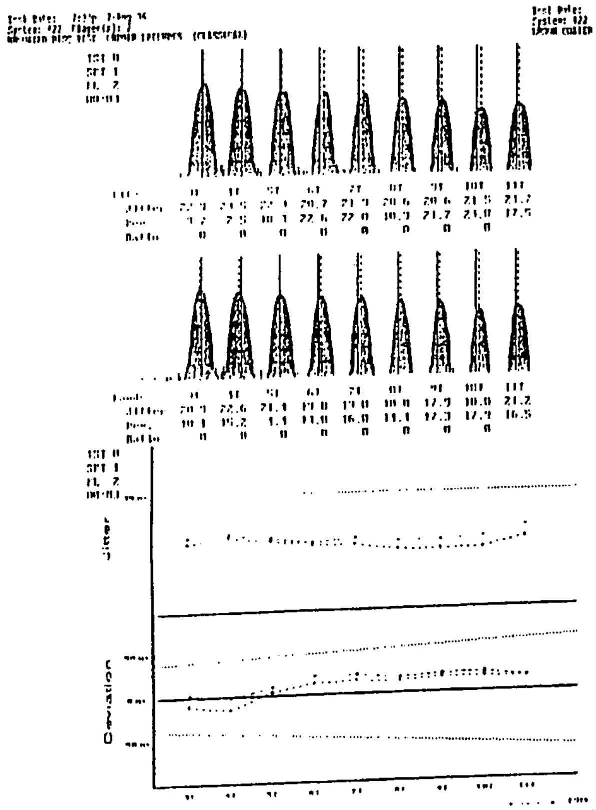


Table 3

Sample Comparison of Test Results of Untreated and LUSON®-treated CD (Chopin Preludes)

	UNTREATED	LUSON®	CHANGE DUE TO LUSON®
DIGITAL			
BLER (220)	0	3	
E11 (220)	0	1	
E21 (200)	0	0	
E31 (200)	0	0	
BRST (7)	0	0	
E12 (300)	0	0	
E22 (2)	2	8	
E32 (1)	0	0	
De-track (track jumping)	1	0	Defect Elimination
ANALOG			
I11 / ITOP	0.619 (0.600)	0.652 (0.600)	▲6%
I3 / ITOP	0.445 (0.300)	0.475 (0.300)	▲7%
I3 / ITOP Range	0.02	0.08	▲400%
SYM	-0.5 (-20.0—20.0)	-0.1 (-20.0—20.0)	▲36%
Rad Noise	12.2 (30.0)	8.6 (30.0)	▼25%
PP Mag	0.069 (0.040)	0.064 (0.040)	▼8%
Jitter / Pits	19.9 (35.0)	17.8 (35.0)	▼11%
Jitter / Lands	18.0 (35.0)	19.4 (35.0)	▲7%
Cross Talk	27.8 (50.0%)	30.0 (50.0%)	▲8%
Deviation / Pits	13.8 (50.0 ns)	-2.0 (50.0 ns)	▼100%
Deviation / Lands	7.4 (50.0 ns)	0.9 (50.0 ns)	▼88%
Scan Velocity	1.33	1.39	▲5%



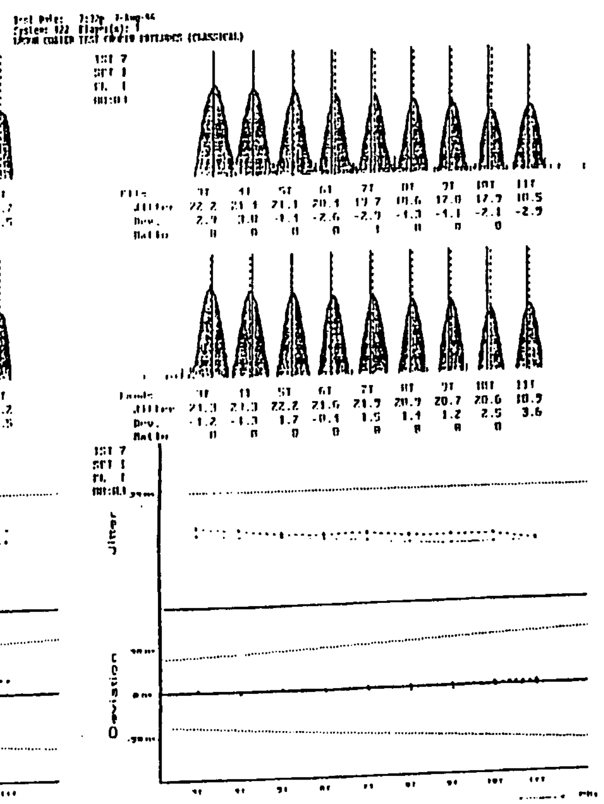


Table 4

Sample Comparison of Test Results of Untreated and LUSON®-treated CD (J Lang)

	UNTREATED	LUSON®	CHANGE DUE TO LUSON®
DIGITAL			
BLER (220)	0	0	
E11 (220)	0	0	
E21 (200)	0	0	
E31 (200)	0	0	
BRST (7)	0	0	
E12 (300)	0	29	
E22 (2)	31	40	
E32 (1)	0	0	
De-track (track jumping) (0)	0	0	
ANALOG			
I11 / ITOP	0.718 (0.600)	0.734 (0.600)	▲2%
I3 / ITOP	0.542 (0.300)	0.525 (0.300)	▼4%
I3 / ITOP Range	0.02	1.0	▲500%
SYM	-8.1 (-20.0—20.0)	-8.1 (-20.0—20.0)	0
Rad Noise	13.1 (30.0)	8.7 (30.0)	▼34%
PP Mag	0.066 (0.040)	0.064 (0.040)	▼4%
Jitter / Pits	17.3 (35.0)	17.2 (35.0)	▼1%
Jitter / Lands	18.2 (35.0)	20.0 (35.0)	▲10%
Cross Talk	36.1 (50.0%)	29.5 (50.0%)	▼18%
Deviation / Pits	16.7 (50.0 ns)	1.3 (50.0 ns)	▼93%
Deviation / Lands	6.6 (50.0 ns)	2.0 (50.0 ns)	▼70%
Scan Velocity	1.33	1.39	▲5%

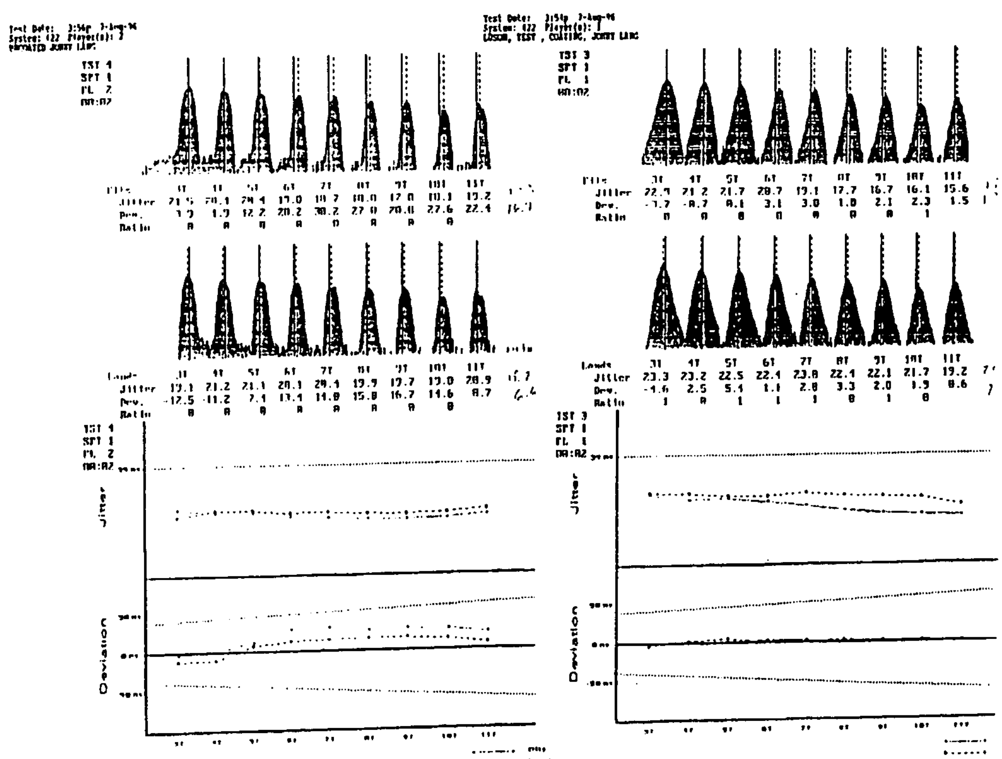
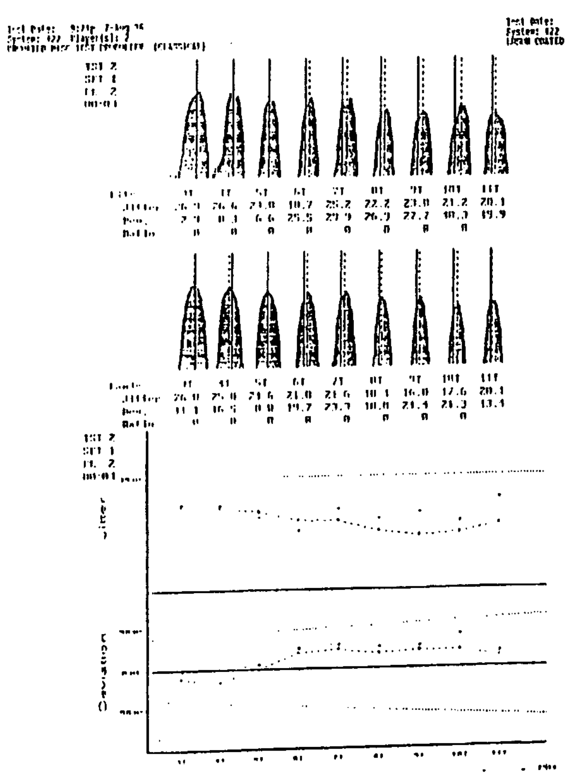
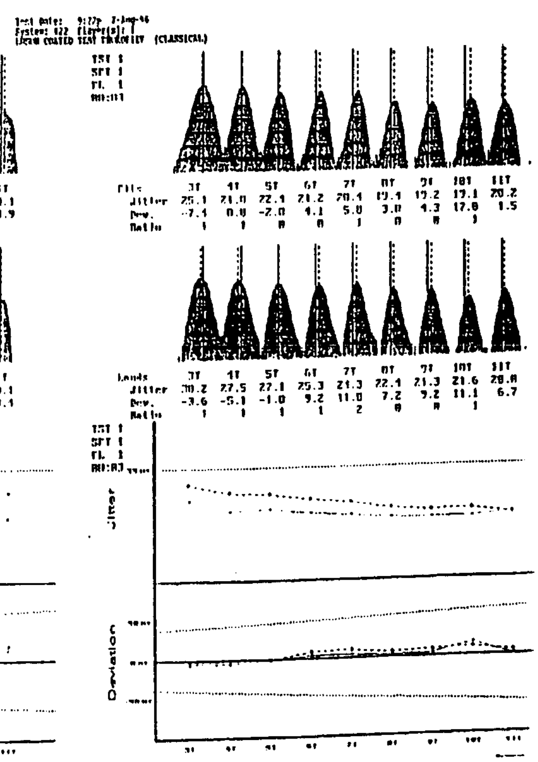


Table 5

Sample Comparison of Test Results of Untreated and LUSON®-treated CD (Prokofiev)

	UNTREATED	LUSON®	CHANGE DUE TO LUSON®
DIGITAL			
BLER (220)	0	0	
E11 (220)	0	0	
E21 (200)	0	0	
E31 (200)	0	0	
BRST (7)	10	18	
E12 (300)	18	0	
E22 (2)	18	56	
E32 (1)	**20**	**0**	**Defect Elimination**
De-track (track jumping) (0)	**3**	**0**	**Defect Elimination**
ANALOG			
I11 / ITOP	0.741 (0.600)	0.781 (0.600)	▲2%
I3 / ITOP	0.440 (0.300)	0.446 (0.300)	▲1%
I3 / ITOP Range	0.02	0.08	▲400%
SYM	-1.9 (-20.0—20.0)	-2.5 (-20.0—20.0)	0
Rad Noise	13.4 (30.0)	10.9 (30.0)	▼34%
PP Mag	0.059 (0.040)	0.050 (0.040)	▼4%
Jitter / Pits	21.6 (35.0)	18.9 (35.0)	▼13%
Jitter / Lands	19.3 (35.0)	22.0 (35.0)	▲10%
Cross Talk	41.9 (50.0%)	38.5 (50.0%)	▼14%
Deviation / Pits	18.4 (50.0 ns)	2.7 (50.0 ns)	▼85%
Deviation / Lands	6.7 (50.0 ns)	4.5 (50.0 ns)	▼33%
Scan Velocity	1.15	1.20	▲4%





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/12161

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B32B 3/00
US CL :428/64.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/64.1, 64.2, 64.4, 64.8

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,706,263 A (LEE et al) 06 January 1998, see abstract.	1, 3, 6-9
A	US 5,381,391 A (YANAGISAWA et al) 10 January 1995, see abstract.	1, 3, 6-9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
28 AUGUST 1998

Date of mailing of the international search report
16 SEP 1998

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/12161

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 2 and 4-5
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The term "rationale" does not define the invention claimed in that the claim could be a method claim or a thought process. Claims 4 and 5 are drawn to both a method of use and a composition and it is unclear which is being claimed.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.